Video Transmission Over CDMA-2000 System

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Abstract-This paper presents a twin-class unequal protected video transmission over mobile channels. As a transport vehicle, we have considered CDMA-2000. A dual priority transmission has been invoked in CDMA-2000 by adopting a relative gain adjustment strategy for transmitting the partitioned video signal. The most challenging aspect of this investigation has been to maintain full compatibility with the CDMA-2000 standard. In particular, for the reverse link where the power allocation is tightly controlled, this strategy has been successfully deployed by taking advantage of the flexibility of its link budget. Finally, we will demonstrate that this strategy can result in a significantly higher quality of the reconstructed video data when transmitted over time-varying multipath fading of IMT-2000 channels.

I. INTRODUCTION

Third generation (3G) wireless systems are expected to provide high bit rate data services of 144 kbit/s to 2 Mbit/s, depending on the radio environment. At the same time, they are to operate reliably in different types of environments: macro, micro, and pico cellular; urban, suburban, and rural; indoor and outdoor. In other words, the 3G systems are expected to offer better quality and coverage, be more power and bandwidth efficient, and be deployed in diverse environments. These high data rates make video transmission possible for a number of important applications such as video conferencing, emergency medical services, search and rescue operations, and site surveys.

Nevertheless, 3G systems, despite their enhanced features, are still severely bandwidth-constrained - particularly for handling video communication traffics. Whilst current methods of video compression accelerate transmission by reducing the number of bits to be transmitted over the network, they have the unfortunate trade-off of increasing signal sensitivity to transmission errors. One effective method of protecting the compressed video signal is to split the coded video signal into a number of separate bitstreams where each can be transmitted via a separate channel having a different degree of error protection [1]. The bitstream splitting can be accomplished by taking into consideration the perceptual significance of coded video, where better protection is provided for the transmission of the perceptually more important bits. In this paper the video splitting technique is based on a separation of the Variable Length Coded (VLC) of the Discrete Cosine Transform (DCT) coefficients within each block. In the splitting process, the fraction of bits assigned to each of the two partitions is adjusted according to the requirements of the unequal error protection scheme employed. Fig. 1 shows a general block diagram of the video splitting and re-synchronization process.

In our previous investigation, the unequal error protection strategy was considered for the other 3G system known as WCDMA [1]. It was shown that a simple repetition scheme could be applied to protect the most error sensitive video data where each bit is repeated 3 times. Since the structure of the CDMA-2000 system is substantially different from its competitor (WCDMA), we have proposed a different dual priority approach that suits the CDMA-2000 physical layer structure. As will be discussed in the following section, the CDMA-2000 physical layer is based on a Direct Spread (DS) multi code channel structure where power for each channel is allocated separately but under certain restrictions. Therefore, unlike the unequal error protection approach, for CDMA-2000 we have considered a different dual priority strategy which is based on exploiting the flexibility of the relative power allocation in its link budget. In this paper we will mainly concentrate on the reverse link due to its more sophisticated power budget specifications.

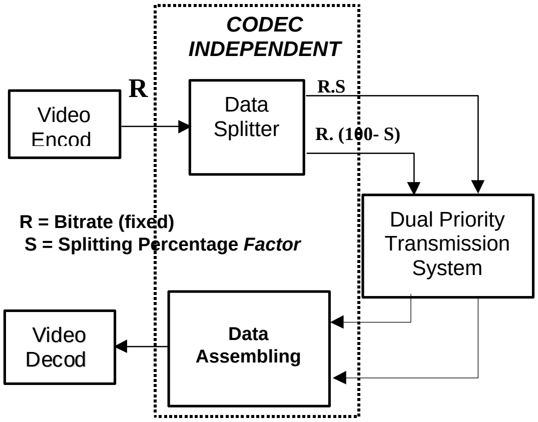

Fig. 1. A general block diagram of the Video splitting process

II. TRAFFIC CHANNEL

The voice and data can be transported via the CDMA-2000 by utilizing one fundamental channel (FCH), and up to two supplemental channels (SCHs) in both forward and reverse links [2,3]. The FCH provides a basic rate of 9.6 kbps (rateset 1) or 14.4 kbps (rateset 2). In addition, the FCH is capable of providing variable data rates of *1.5, 2.7. 4.8,* and up to *9.6* kbps for rateset *1* and *1800, 3600, 7200*, up to *14400* for rateset 2 where the rates can be changed on a frame by frame bases. The use of SCH1 and SCH2 offers two additional higher rate channels, which will be considered here for transmission of video signals. Both the forward and reverse link can operate at the chipset of $N*1.2288$ Mcps where N is defined as the spreading rate and can have a value of *1, 3, 6,* etc. For operational purposes, the selection of different spreading rates (e.g. $N=1$ or $N=3$), the ratesets, or the possible information rates are classified as Radio Configurations (RC). For instance, Radio Configurations 1 and 2 are designed for backward compatibility with the existing IS-95 CDMA system. Since in this paper our main objective is to evaluate the transmission of audiovisual information over the reverse link of CDMA-2000 system, the following provides a brief overview of its traffic channel characteristics.

A. Reverse Link

The traffic signal in the reverse link consists of five direct spread (DS) channels [2]. These are the Reverse Pilot Channel (R-PCH), Reverse Fundamental Channel (R-FCH), Optional Reverse Supplemental Channel-1 (R-SCH1), Optional Reverse Supplemental Channel-2, and Reverse Dedicated Control Channel (R-DCCH). In addition, a total of six radio configurations (RC) have been specified so far for the reverse link (this number may rise with future expansion of the IS-2000). For our video conferencing application we have considered RC=5. This configuration corresponds to the chip rate of 3.68 Mcps and is based on the rateset-1 (i.e., basic rate of 9.6 kbps). The coding structure of the R-FCH and R-SCH are similar and their detailed specification can be found in [3]. TABLE I depicts some of their most important parameters for RC=5.

TABLE I

Important parameters of the R-FCH and R-SCH

Input Data rate (kbps)	Convo-lutional Rate	Symbol repetition Factor	Puncturing pattern	Coded Symbol Rate (ksps)
(1.5)	1/4	16x	1 of 5	76.8
(2.7)	1/4	8x	1 of 9	76.8
(4.8)	1/4	4x	None	76.8
(9.6)	1/4	2x	None	76.8
(19.2)	1/4	1x	None	76.8
(38.4)	1/4	1x	None	153.6
(76.8)	1/4	1x	None	307.2
(153.6)	1/4	1x	None	614.4
(307.2)	1/3	1x	None	921.6
(614.4)	1/3	1x	None	1,8432

For transmission, the reverse channel signals are orthogonally spread and combined using quadrature spreading. Orthogonal codes are employed to multiplex the reverse channels using the Walsh function. Fig. 2 shows the spreading, combining and modulation characteristics of the reverse link for RC=5. As shown in this Figure, the spread reverse channels are scaled by their relative gains, which are set in accordance with the reverse link budget. For the transmission channel we have considered the IMT-2000 Vehicular Model A, as specified by the standard [3]. This model takes into account both the slow and frequency selective fast fading. After fading channel, white Gaussian noise

(WGN) is added to simulate the effect of overall interference in the system, including thermal noise and inter-cell interference.

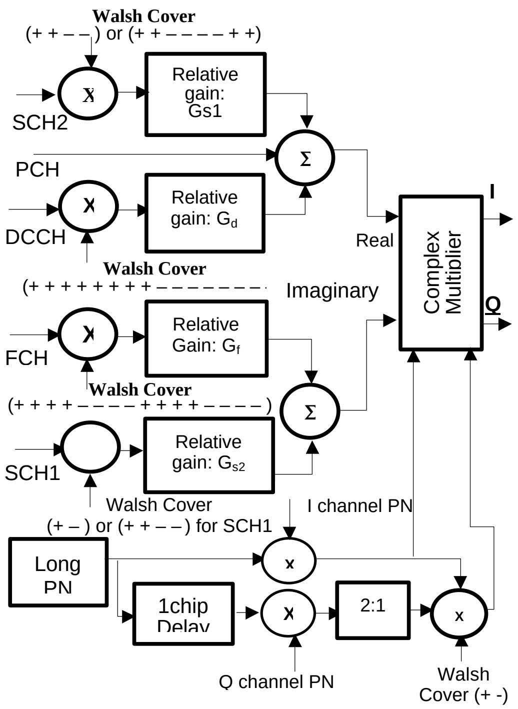

Fig. 2. Spreading and modulation characteristics of the reverse link for RC=5.

As for the receiver, we have considered a six-finger rake receiver. The Rake receiver is a coherent receiver that attempts to collect the signal energy from all received signal paths that carry the same information. The Rake receiver therefore can significantly reduce fading caused by these multiple paths. The channel despreader takes the outputs from the Rake receivers and recovers the channel data, by despreading the outputs using the appropriate Walsh function.

B. Link Budget

As shown in Figure 2, the spread channels are added together (including the pilot) as the chip rate is the same after spreading. The spread, summed data is then complex multiplied with the pilot PN (short) sequence, and filtered. The channel powers, are determined by the link budget. The reverse link power budget is based on the equations specified in the Cdma2000 Physical Layer [3]. The output power of each Code Channel (e.g., R-FCH, R-SCHs, R-DCCH) is set by the mobile station relative to the output power of the Reverse Pilot Channel (*R-PCH*). Therefore, the first task is to determine the output power of the *R-PCH*, *Ppilot* using open loop power estimation. Then, the output power of every Code Channel, *Pcode* can be calculated, based on *Ppilot* and stored parameters in the mobile station. The calculated *Pcode* is then applied to the Relative Gain block shown in Fig. 2, so that every Code Channel can be adjusted to its desired output power for transmission. In our strategy, the relative gain adjustment for mean pilot output power is calculated assuming that there are no closed loop power corrections.

III. DUAL PRIORITY STRATEGY

In our strategy, the fundamental channel has been used for transporting the audio portion of the video conferencing information. However, for our dual priority transmission system we have decided to use both supplemental channels where each is used to transport one of the partitioned bitstreams. In order to impose a dual priority transmission system, a new power allocation strategy has been considered. Fortunately, such a strategy can be easily incorporated into the CDMA-2000 reverse link budget. For instance, the stored parameters in the link budget consist of a parameter, which is defined as: RLGAIN_SCH_PILOT[i]s [3]. The function of RLGAIN_SCH_PILOT[i]s is to perform a gain adjustment of the R-SCH[i] (i.e., i=0 or 1) relative to the reverse pilot channel (R-PCH).

In order to maintain the same total transmission power of the reverse link, the power increase in the high priority R-SCH (e.g., R-SCH1) should be compensated by the same amount for the lower priority R-SCH (e.g., R-SCH2). We should emphasis that the power allocation also depends on the data rate operated on that Code Channel. If the same data rate is selected for both supplemental channels, their relative powers should be increased and compensated by exactly the same linear amount. It should be noted that, in accordance with the IS-2000 link budget specifications, the code channel powers could go up or down by the steps of 0.125 dB. This may slightly change the total transmit power but the effect would be marginal. For selecting differing data rates for R-SCHs, a new parameter is added to the link budget to appropriately control the power allocations for both supplemental channels.

IV. EXPERIMENTAL RESULTS

Recently at NIST we have designed and developed generic simulation models and libraries for CDMA-2000 using Signal Processing Worksystem (SPW) tools. These models include all the radio configurations defined by the IS-2000 standard [4] for both forward and reverse links. In addition, the link budget for the reverse link has been fully implemented in accordance with IS-2000 specifications for test and performance evaluations.

For this investigation, transmission of partitioned video using the CDMA-2000 reverse link with radio configuration 5 (RC=5) has been considered. This configuration corresponds to the chip rate of 3.68 Mcps and rateset 1. For both supplemental an information rate of 34.8 kbits/s was selected and fixed 9.6 kbits/s was considered for the fundamental channel.

The carrier frequency was set at 1.9 GHz. In our experiments, the mean output channel powers were calculated by the reverse link model in accordance with our modified link budget. All the initial values and relative gain adjustments in the link budget were set in such away that the R-SCH1 was transmitted with higher power relative to the R-SCH2. As discussed earlier, the mean pilot channel power was first calculated by our SPW model link budget. This was done in accordance with the user specified Received Power Spectral Density (PSD) at the mobile station’s antenna connector.

The initial results are presented in terms of the PSD of the total received noise (interference + thermal) in dBm/3.68 MHz versus Bit Error Rate (BER) in Fig. 3. These results are based on the unequal power allocation for the supplemental channels. The important parameters in which these results were obtained are tabulated in TABLE II.

The final stage of our experiments was concerned with the transmission aspects of the partitioned video signal over the CDMA-2000 reverse link. In our experiments a number of well know sequences with the QCIF format were used. The sequences were coded at the bitrate of 68 kbit/s and, together with the additional synchronization bits, were transported via two supplemental channels (each 38.4 kbits/s). This required a partitioning percentage factor of 47% (please see Fig. 1). This is to allow the additional synchronization bits for the second partition. Finally, in our presentation we will demonstrate the quality of the received video data under various test conditions and channel environments.

TABLE II

Test Parameters and mean power values

Channel	Information Rate (kbit/s)	Power (dBm)	RLGAIN_ SCH_PILOT	Receive d PSD (dBm)
R-PICH	Unmodulated	-3.0	-	-76.5
R-FCH	9.6 Fixed	-.625	-	“
R-SCH1	38.4	5.5	7	“
R-SCH2	38.4	3.375	-8	“
R-DCCH	9.6	-0.625	-	“

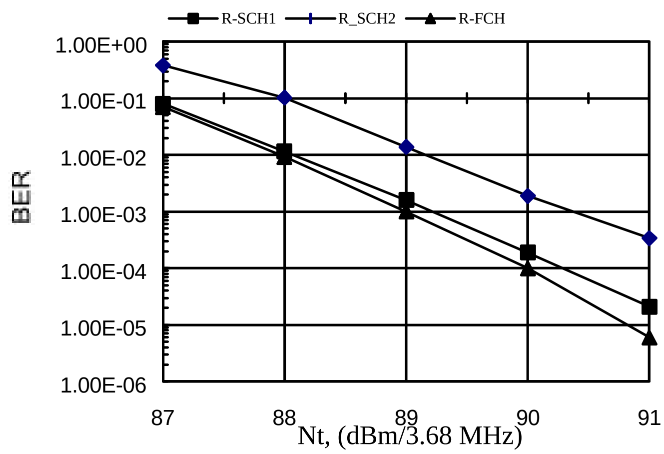

Fig. 3. BER Performance of the R-FCH, R-SCH1, and R-SCH2 with unequal power allocation for the supplemental channels.

REFERENCE

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